NAMG

Gamification of mathematics concepts (Not Another Multiplication Game)

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0.1 Abstract

This document presents the end-of-degree project about NAMG, a tablet video game with 2D graphics, pixel art style and made with Unity. The goal of the game is to be as educational as possible while remaining fun and challenging to the player. Namg has a turn-based fighting game appearance and is partly like that, but its story and its world serve as an excuse to use a more educational mechanic. This mechanic consists of creating rectangles by choosing its width and height in order to match its area with the number indicated by the game. Therefore, the player has to figure out the components of the multiplication and then they can see, using the rectangle, a visual representation of the multiplication. This mechanic is also based on overlapping the rectangles to solve the puzzle. The objective is to teach or bolster multiplications concepts in an amusing way without the player realizing the educational aspect of the game.

0.2 Keywords

Didactive, Math, Playful, Serious Game.

Nang

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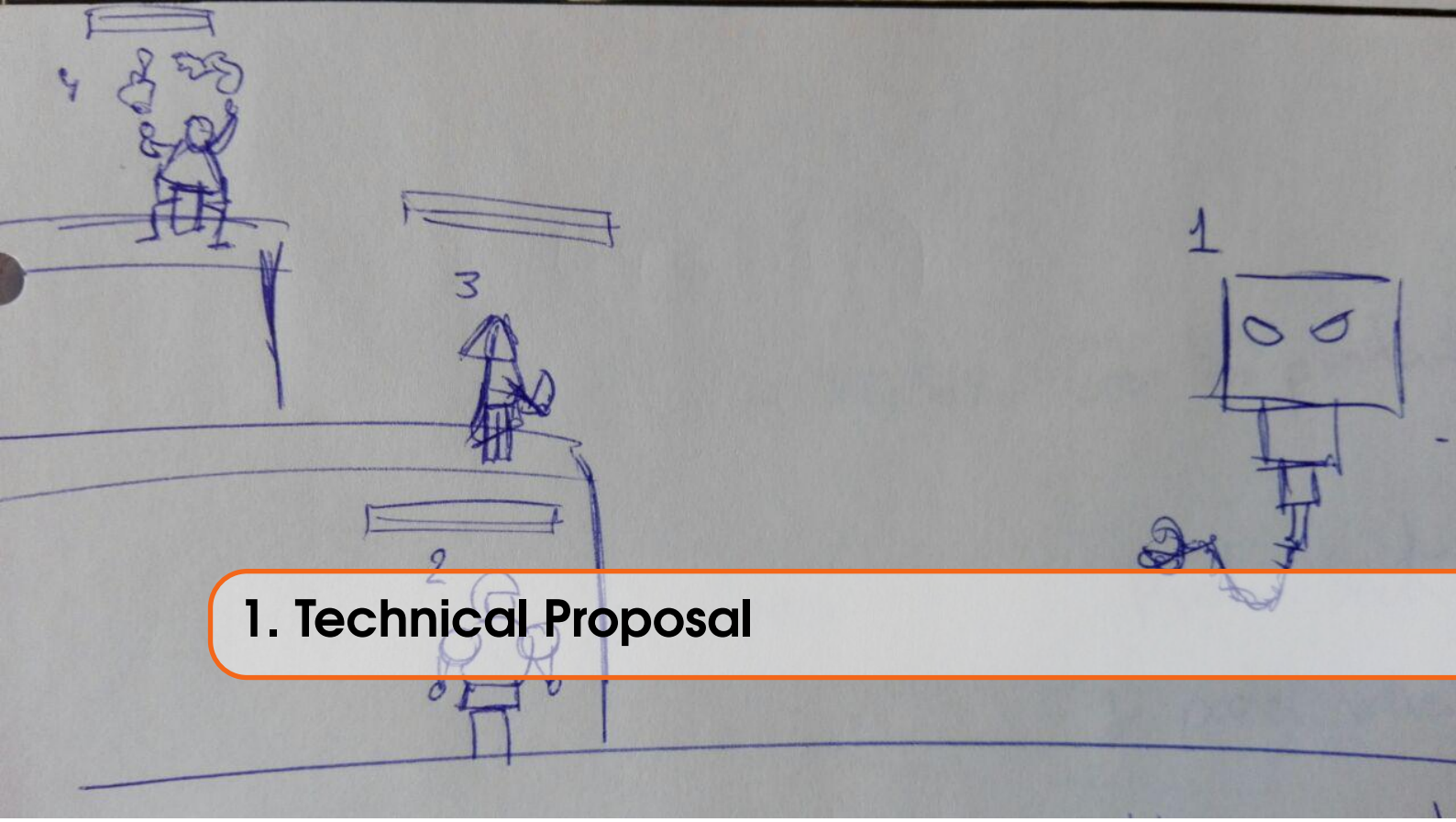


1. Technical Proposal

1.1 Introduction

Since video games were seen as a possible way to make Serious Games[1] in 2005, they have proved to be a very suitable way to teach many kinds of concepts. That is why, there is a large number of games which try to teach mathematics concepts, especially related to multiplication. Unfortunately, most of this games look like one of this examples. Math vs Zombies[1] and Pearl's World [2] The gameplay is based on multiplication, normally it is just select the correct result from a group of numbers or write it down. Even when the game is very colorful and has a lot of jazzy environments, the player ends up bored, because the games are still notebooks with gaps, waiting for you to fill them with the correct result. The video game as a result of this proposal will use a different gameplay as the examples presented before. In order to explain the game as itself, it must start from the narrative of the game which is used to explain the gameplay and the game mechanics.

The player will control Namg, the smith of a quiet town until a portal located in the mountains lets pass some monsters from the pixel art dimension. Three warriors will have to defeat the monsters and close the portal; a knight, an archer and a mage. The problem is that their current weapons do not work anymore since everything that comes near the portal will become pixel art, even the warriors themselves. That is why Namg will be with them during the battles and will craft for them pixel art objects in order to do actions like attack, defend, heal and special attack. Attack, will reduce enemy's health, defend will reduce the damage if the warrior gets attacked, heal will increase the health of that warrior and the special attack will be determined by the warrior and the object that the player will craft, nevertheless, it will do any of the previous effects but incremented. Every warrior has his own strengths and weaknesses.

The fights against the monsters will be by turns, when the player is in one of our warrior's turn, they will choose one of the for actions to do. Then they will need to craft an object related to the chosen action. This object will be in pixel art, that means, it will be made by pixels and there it is where the educative gameplay appears.

The main scene of the game will be like Figure [1.1], in which upper left corner it can be seen

[1] www.microsoft.com/en-us/store/p/math-vs-zombies/9nblggh08h02
[2] www.fun4thebrain.com/multiplication/pearlsworldmult.html

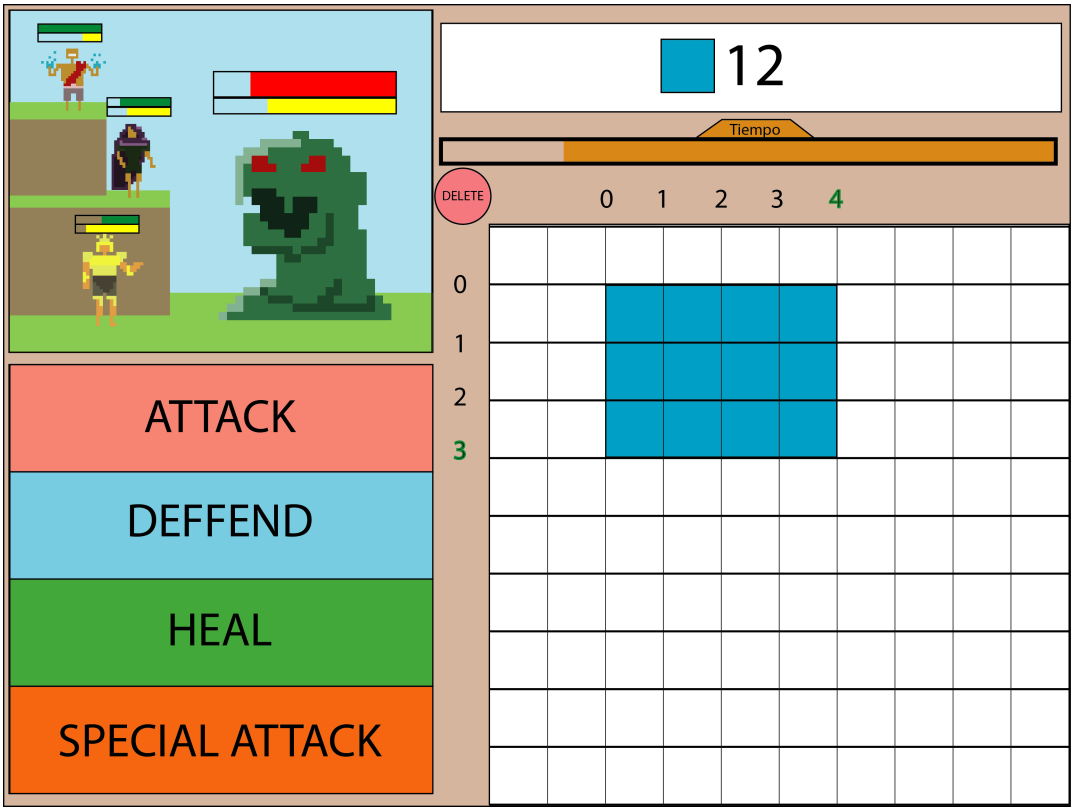


Figure 1.1: Skecth of the gameplay screen of Namg.

the warriors and the monster that the player must defeat, just below there the actions that they can do can be seen. The rest of the screen is related to the crafting system of the game and it is explained below.

In order to craft any object, on the top of the screen it will appear a number referring to the number of pixels that are needed, next to a square the same color as the pixels that are needed.

Below that sign, there is a 10*10 board, where every cell represents a pixel. If the object needs 12 blue pixels, the player will press the board and slide them finger to any direction in a way that the line they draw will be the diagonal of the rectangle. While the player is sliding them finger at the edges will appear the number of rows and columns that the player is using being the position (0,0) where the player started the rectangle. If the rectangle does not solve the puzzle the player can erase it pressing a button and create another rectangle. In this case, the player can create a 4*3 rectangle, something remarkable about this game mechanic is that there are more rectangles to solve the puzzle like 3*4 or 2*6.

Using this mechanic the player relates the numbers from the width and the height from the rectangle to the result of the multiplication and he knows he is right not just because the games say it but for the rectangle being the graphical representation of the result of the multiplication.

On the screen, below the sign there will be a bar that will reduce with time, hence the sooner the object is crafted, the more powerful it will be. If the bar consumes itself there will be no bonus.

As an added game mechanic, there can only be created red, blue and yellow rectangles, that means if a secondary color is needed, like lilac or green, the player will have to figure out which colors to mix to obtain that color and then place the rectangles so they overlap.

Even when the game is using these educative mechanics, the objective of the gameplay it is not just creating rectangles of a certain area, it is mostly choosing between the possibles actions in every turn in order to defeat the monster.

1.2 Objectives and tasks

1.2.1 Objectives

1. Get a full-featured game: a game that can be played from beginning to end without errors and show the story and the mechanics.
2. Give the game a complete artistic style in tune: a 2D style for the game that is child-friendly and also shows the emotions of the characters and the nature of the world itself.
3. Design a game that allows consolidating multiplication concepts by applying a mild game flow: a game play that helps you to improve your multiplications skills but also it's funny and rewarding in another aspect like the battles.

1.2.2 Tasks

Table [1.1] shows the tasks of the project. The main ones are a follows:

- Make all the necessary 2D art for the game.
- Programme the mechanics of the game.
- Design the narrative of the game.
- Make a Game Design Document (GDD) [2].
- Show the project.

1.3 Related Subjects

This section explains the relationship between the sections of the project and the subjects of the course. Since Namg is an application, tasks to complete include many career fields, from designing and sketching a character, to schedule them actions in the game. That is why it is intended to use knowledge of all subjects, however, will be explained those that are more related to the project.

1. 2D Design - VJ1209. The learning outcomes of this subject are the ability to create animations using differents software and the ability to create many styles of 2D art for video games.
2. Knowledge for the design of didactic video games - VJ1238. From this subject, it will be drawn the knowledge to comprehend how the mechanics and the story should be in order to be entertaining to kids who want to learn but also to feel rewarded.
3. Game Engine - VJ1227. During the course of this subject it was taught how Unity works and the characteristics of the tools that unity let you make video games.
4. Video Game Art - VJ1223 The learning outcomes of this subject are the ability to make concept arts in order to design the characters and the environments, also to create the final art of the game.

1.4 Tools

1.4.1 Art

- Open source Krita[3] will be used to create the whole vectorial art of the game, including the sprites and the environments.
- the web Piskel[4] with its online software will be used to create the concepts of the pixel art objects.

1.4.2 Programming

- The game will be made with the Unity engine [5].
- To create the dialogues scenes in the game it will be used the plugin Fungus [6].

Table 1.1: Tasks and time

ID Task	Description	Hours
Art		
A1	3 Sprites per each one of all the 6 characters to use in dialogues	36
A2	The pixel art version of every character ant the 3 monsters	18
A3	The animations of the 3 warriors and the 3 monsters	12
A4	The 2 environments of the game	5
A5	The pixel art objects	8
A6	Animations on the environment	6
A7	Special attack animations	4
A8	UI	5
A9	Logo	2
Programming		
P1	The tactile interaction with the screen	6
P2	The health of the warriors and the monsters	24
P3	Algorithm to select the object to make and its recipe	24
P4	Algorithm to check the rectangle made	20
P5	Flowchart between screens	6
Documentation		
D1	Lectures about TFG	8
D2	Technical Proposal	12
D3	Game Design Document (GDD)	40
D4	TFG Document	45
D5	Project Defense Video	2
D6	Project Defense Presentation	2
Game design		
G1	Dialogues to tell the story	10
G2	Find music and effects	5
Total		300

1.4.3 Music

- The music or the different effects will be from webs like Jamendo[7],Free sound [8] or Free Music Archive [9] .

1.4.4 Documents

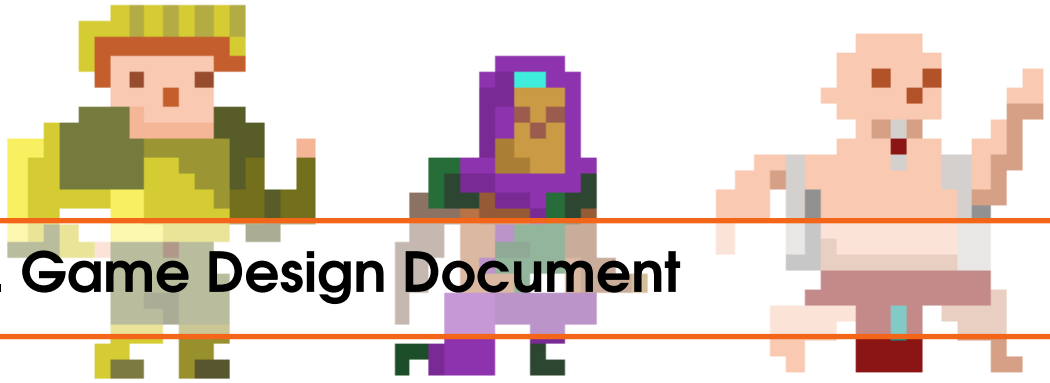
- The documentation about the process will be made using the web Overleaf [10] and the system LaTex.

1.5 Expected Results

With this proposal it is intended to develop NAMG, giving, as a result, a visually attractive and funny game. Also, it will help to show that didactic elements can be in a game without being the main mechanic. One of the first attempts to create a new style of Serious Games that use educative mechanics in a way that is funny and gratifying for the player.

This game will be an app for a tablet. When the player starts the game, a small introduction will

be shown to introduce the characters and the story, and also giving a logic context to the mechanics. After that, the battles would begin with the mechanics explained above so that the player performs dozens of multiplications mentally without the game explicitly indicating it.



2. Game Design Document

2.1 Overview

The game Namg is a 2D educative app for a tablet. In the Game the smith Namg will help Pixus, a creature from the pixel art dimension, to close the portal which leads to its dimension. Unfortunately, three monsters have the components of the key that close the portal. Three warriors decide to help Pixus. The player will control the actions of those warriors during the battles and also will have to use multiplication elements to craft the weapons and artifacts for those warriors. Between the battles, smalls dialogues will tell the story and the intentions of the characters.

2.2 Theme and Genre

This game is aim to be an educational game, a category within the category of serious games. The objective is to teach or bolster multiplications concepts. Based on the crafting mechanic, part of this game could fit in the mental ability category, however, the whole battle mechanic is based on the turn-based combat genre. Due to the dialogues in the game, part of the genre of conversational adventure has been used to tell the story.

2.3 Core Gameplay Mechanics

In the game Namg, the player leads a group of three warriors during some battles while creating their weapons and artifacts.

2.3.1 Battle

During the battles, the player will choose from four different actions for each warrior, attack, defend, heal or special attack.

2.3.2 Crafting

After choosing the action the player will have to create rectangles to obtain the number of pixels of each color that are needed to craft the object.

2.4 Targets

This game is intended to be played mostly by children, using a tablet.

2.4.1 Target Market

This game is supposed to be funny enough to be played by anyone. In order to achieve that, the main objective of the game is to win battles and not to memorize multiplication tables, although it is an important part of the crafting mechanic. However, the story and the simple mechanics are focused on be child-friendly, especially to kids between second and third grade when they learn multiplication for the first time.

2.4.2 Target Platform

In order to be played by as many audiences as possible, there will be two platforms on which anyone could play the game. The first one is the one platform that was thought. Due that the whole game is meant to be played tactilely, the tablet is the best option, many children have already become accustomed to it and it can be used anywhere. However, to increase the possible audience there would be also a computer version where the cursor makes the tactile interaction.

2.5 Monetization

At first, this game will be free-to-play in order to study if it really helps to improve children with multiplications. If the results are positive, it could be made a game with same mechanics and characters but with more battles in order to augment the game time and sell it like any other video game.

2.6 Influences

2.6.1 Influence 1

Video game: Child of light[11] - the most remarkable influence is its turn-based battle mechanic where heroes and enemies are places at different heights on the screen as can be seen in Figure 2.1. Also, the warriors have their own special attacks and every turn the player selects which action they will do, however, this game has more mechanics that will not be used in this project.

Figure 2.1: Battle screen of Child oh Light.

2.6.2 Influence 2

Video game: Super time force[12] - In this game the characters are in Pixel art, even when they are small and simple, they reflect their own personality. This kind of style will be used during the gameplay and also to the objects in order to reflect the effect of the portal of the pixel art dimension.

Figure 2.2: Screen of the gameplay of Super Time Force.

Influence 3

Video game: Shantae[13] - During the game, dialogues are shown next to their character, normally showing an expression, using this vectorial style and this method it can be shown to the player how the characters behave o how they feel about what they are saying.

Figure 2.3: Screen of the dialogues of the game Shantae.

2.6.3 Influence 4

Video game: Resident Evil 4 [14] - The influence from this game has nothing to do with zombies. In this game the player has one briefcase to carry all the weapons, ammo and consumables, as the game gets more difficult and the zombies are harder to kill the player spends more time preparing the briefcase for the next zone, until the point when the player does not see weapons or consumables, they see rectangles that need to be placed in a way that everything fits, that is when the player starts

to use multiplications tables to know that if you have a space of 4*2 you can carry four 1*2 ammo or one 3*2 gun and one 2*1 ammo. In Namg, the table of the gameplay would be the briefcase and the objective is to explore all the game mechanics that can be used with the rectangles.

Figure 2.4: Screen of the briefcase of Resident Evil 4.

2.7 The elevator Pitch of the game

With the game "Namg" everyone with a tablet can test their multiplication abilities in an amusing way, creating rectangles whose area is the number specified by the game. The player will have the roll of Namg a smith that has to follow a recipe and create rectangles of different areas in order to break them into pixels and use those pixels to create pixel art weapons and artifacts. During the battles, The player will command three warriors and in each turn, they will choose an action for the warrior, after that each action need a pixel art object, for example in order to protect a warrior the player will have to create certain rectangles to craft a pixel art shield.

The gameplay is based on choosing the correct actions during the battle and also providing the warriors with the pixel art objects. The intention is that the goal is to win the battles and showing the multiplications like a necessary tool to get there. In this way when a kid plays the game after wining one battle, they have made tens of mental multiplications.

2.8 Project Description (Brief)

The main objective of the project is to create a "fun" serious game. A game that helps children to understand and enhance their multiplication abilities, but also still having an entertaining gameplay. Made in Unity 2D whit vectorial art for the characters and pixel art for the gameplay objects, with the tablet as a final platform for the game.

2.9 Project Description (Detailed)

The game Namg is about using an educative mechanic in a game in a way that the player sees that mechanic necessary and meaningful within that world, also it tells the story of Pixus and how the player helps him. The game will be made in Unity 2D because it is a well-known game engine

and also it has been used in some of the subjects of the degree. The programming language for the scripts of the game will be C sharp. To make the vectorial characters it will be using the free software Krita with a similar style like the influence 3, different characters with a lot of expression in their faces to empathize the dialogues, and also flat colors on their clothes. The pixel art will be as simple as the one shown in influence 2 this will be used to excuse the crafting mechanic as the weapons need to be made by pixels. This game is intended to be played by people who as the gameplay progress are getting more familiar with multiplication concepts but also still feeling like they are playing a complete game with the story and other mechanics.

2.10 What sets this project apart?

As it is presented in the abstract of this document, the majority of educational games just want kids to choose the correct answer of the multiplication, by clicking on the screen or writing it down, after that another multiplication appear and the cycle is repeated. This type of games does not present complete characters with which a child can empathize, and usually, they do not have a story beyond explaining why the main characters needs the player to answer the multiplications, sometimes is the work of the main character or it does not follow any logic and is only a poor excuse. One example would be the gameplay of "Maths vs Zombies" as it can be seen in Figure[2.5]. The game presents

Figure 2.5: A example of an educational game without characters or a story.

the characters and expresses their thoughts and behaviors during dialogues, also the whole story is built around the necessity to bring logic to the crafting mechanic. The weapons need to be made by pixels because Pixus and the rest of the monsters are from the pixel dimension and vectorial weapons do not hurt them. This more elaborate excuse along with the battle mechanic, make Namg an equal educative but more fun experience.

2.11 Core Game play Mechanics (Detailed)

2.11.1 Battle

In every battle, there are 3 warriors and 1 monster. Each warrior has their own bar to fill in order to get a turn. When it is their turn there are 4 possible actions to do: attack, defend, heal and once their special attack is charged they can use their special attack.
Each warrior has their own bar above their head, once is full, 4 actions appear below the battle screen, when the player selects one of them, then they have to create a pixel art object related to that action once they have the object made, the warrior do the action and their turn ends.

2.11.2 Crafting

Once the player selects the action, they have to create the object. Above the table, it shows the number of pixels of every color that are needed. Then the player clicks in the table and slides them finger in order to create a rectangle whose area will be the number of pixels of that color that are needed.

Educative part: The player sees the number, then they have to think which 2 numbers do you multiply to get that result. Once the player figures out one of the possibles solutions, they put their finger on the screen ant press one cell of the table, that cell will be a corner of the final rectangle, when the player slides their finger the cells that they touch will be part of the diagonal of the rectangle and where them stop it will be the other corner of that rectangle. In that way, with a simple and fast move, they can create the rectangles. While the player is creating the rectangle, the number of the rows and columns that they are using will be shown on screen as can be seen in Figure 1.1.

2.12 Story

2.12.1 Brief

In a small village the opening of a portal will lead the entrance of three monsters. A brave smith named Namg will meet Pixus, a creature from the other dimension, and together will help three warriors to defeat the monsters and close that portal.

2.12.2 Detailed

The story begins with Pixus the prince from the other dimension after his father gets really sick, his coronation is being set out, however, he does not see himself as a king so he took the inter-dimensional key and escapes through. Once the town realizes he is missing, the two most unforgiving warriors and the general of the court cross the portal to find him. Once they find him on the mountain, they break the key in three fragments to prevent the prince from creating more portals and each one grabs a piece, hopefully, Pixus is able to escape down the mountain and reach the first smithy he sees to ask for help. That is the point when the game starts the story.
Pixus knocks the door of Namg's home and asks her if she can repair his key, then three warriors come to Namg's house also for help, they were trying to beat the monsters but their weapons were useless and one of them is hurt. Pixus agree to teach Namg how to create weapons that can defeat the monsters with the condition that they give the key to pixus once the portal is closed.

With every battle, the monster defeated will tell something that reveals a little about Pixus, at the end the warriors will think that he is a famous criminal of the other dimension because that would explain why the are monsters looking for him. Nevertheless, when the player arrives at the last monster, the uncle of Pixus named Kulxos tells all about Pixus's identity, and that is because he is planning to leave the prince behind, in order to go back to his dimension, close the portal and once the king dies he will be the new king.

Figure 2.6: Cutscenes

1	2	3
Pixus talking with Namg about the portal and telling the warriors that he can help to heal one of them (this will be the excuse of the tutorial which will teach the player how to craft an object to restore health)	After the tutorial all the warriors are ready to go to the mountain and Namg accept to go with them.	After defeating the first monster the player will know that the monster is after Pixus but they don't know why.
4	5	6
After defeating the second monster the player will know that Pixus is very famous in his dimension, so the warriors will think that he is a criminal the player won't know the past of Pixus either.	Before the last battle, Kulxos reveals his plan.	Pixus accept to be the next king and closes the portal.

Once the last monster is defeated, the king crosses the portal and talks to Pixus, he says he is not ready to reign, but then the king makes him realise that he has been leading this team every battle, so he is more than ready to be the king, then Pixus with all of his people closes the portal from the other side.

2.13 Dialogues

The story will be told by dialogues between the characters. There will be 6 dialogues, as shown in Table 2.6

2.14 Tutorial

Between the first and the second dialogue, the player will play the tutorial of the game. In the tutorial one of the warriors, the mage, has been hurt and none of the vectorial potions work, so Namg will have to create a pixel art Apple to restore the heal of the warrior, as shown in Figure 2.7, this apple is made by 30 red pixels, 4 yellow pixels, and 4 green pixels. Starting with the 30 red pixels the player can make a 10*3 rectangle or a 5*6 rectangle using the crafting mechanic, then the 4 yellow pixels can be made with a 4*1 or a 2*2 rectangle, however the player doesn't have green pixels but they have blue ones, so a dialogue will appear to make understand the player that they have to make a 4*2 o an 8*1 rectangle in order to cover 4 yellow pixels with 4 blue pixels to create the green ones. One of the possible solutions to the tutorial are shown in Figure 2.8

2.15 Assets Needed

In the game there will be only 2D art, during the dialogues the characters will be seen in a vectorial style, while in battle they will be in pixel art like the objects crafted during the game, this is used as an excuse for the story. They have to create pixel weapons because the weapons of their dimension are all vectorial and they don't work against pixel monsters.

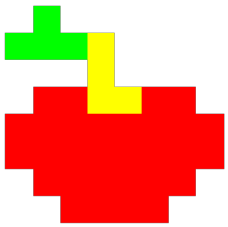


Figure 2.7: Pixel art object of the tutorial of the game.

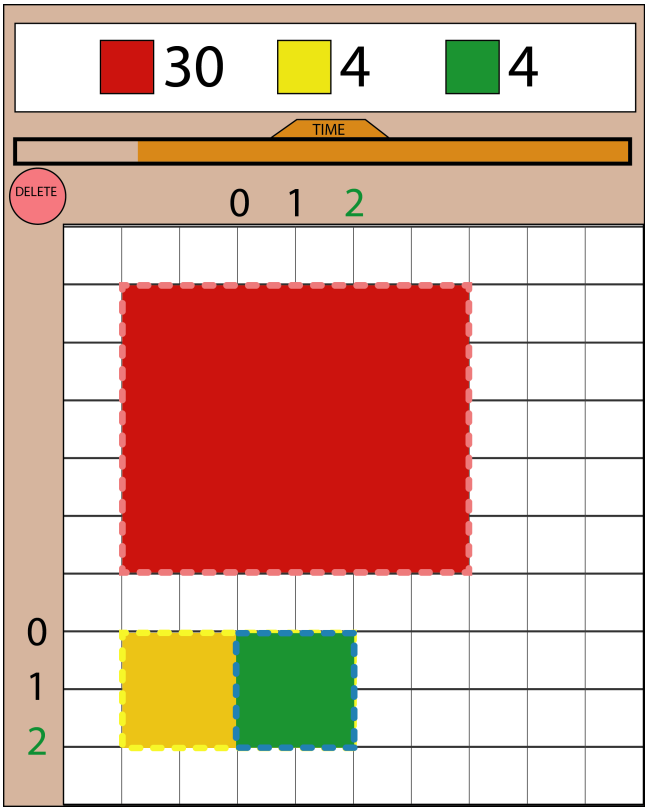


Figure 2.8: A possible solution of the tutorial.

This game will also have one background for the dialogues and another for the gameplay. A Logo will be made for the game and also some animations in order to make the background and the characters come to life.

2.15.1 Vectorial

This style will be used to make sprites similar to the Influence 3, very simple mostly focused on showing the characters emotions as can be seen in Figure 2.9

- Between two and three sprites of the same character will be needed in order to be able to show different emotions during the dialogues.
- One Background will be needed for the main menu and then another version with the portal on top of a mountain during the first dialogue.

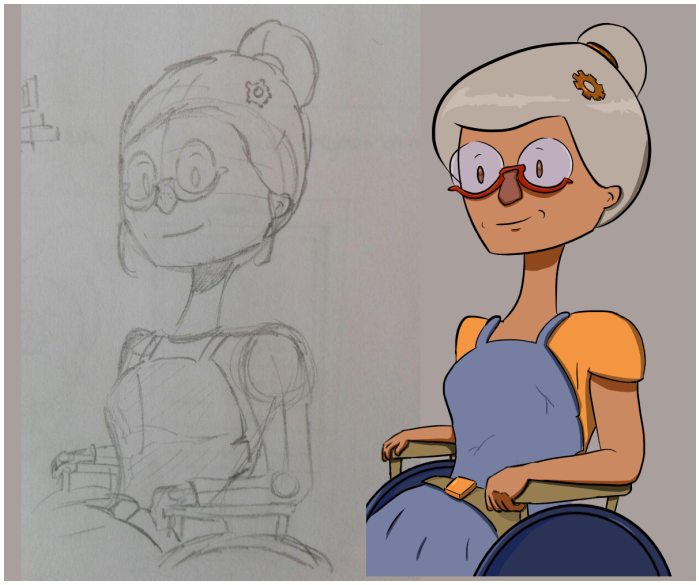


Figure 2.9: The vectorial style of Namg from the concept.

2.15.2 Pixel

This style will be used to make the objects and the gameplay screen characters. With this style, every pixel represents a cell of the crafting table making sense of the educative mechanic using the rectangles.

- All the battle objects, like potions or weapons, will be made using this style as can be seen in Figure 2.10.

2.15.3 Animations

For each possible action of a warrior, it will be a different effect and that effect will be shown with a pixel art animation.

- Between four and five animations will be made because a special attack can activate special animations.

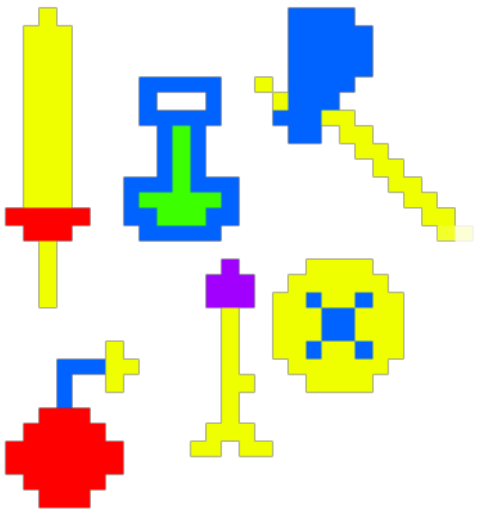


Figure 2.10: Some pixel objects of the game.

2.16 HUD

During the whole gameplay, there will be a pause button to pause the game, then there will be two buttons, one to keep playing the game and the other one to exit. The HUD of the main menu will be only a button to start the game, during the dialogues a box will appear at the bottom of the screen with the text of the dialogue, and finally, during the gameplay, there will be a HUD for the battle and another one for the crafting mechanics. The HUD of the battle will show the heal of each warrior and the wait for the turn, also it will show if the warriors are under any effect. On the right side of the screen, there will be the crafting HUD showing the recipe of the object, the reset button and the rows and columns of the table.

2.17 Text

All of the stories of the game will be read through the dialogues from the first scene and the scenes between battles. While the text it is written on the dialogue box the character that is speaking will be on the scene during these scenes the characters will go in or out depending when they speak. Furthermore during the battles after crafting an object the number related to the effect of the object will be shown rising from the character position, for example, if a warrior gets hurt and loses twenty points of health, the number twenty will appear on the screen.

2.18 Sounds

In this game, the sounds are used to give to the player as much feedback as possible and also to whip up the environments.

2.18.1 Background Music

In the scenes where the player reads the story, it will sound a soft music to not disturb in any case the player. Nevertheless, during the battle scenes, it will sound a song with a faster beat.

2.18.2 Effects

This sounds will give feedback to the player, sounds like healing, getting hit or charging the special attack.

2.19 Code

The scripts needed for this game will depend on which mechanic are they for.

2.19.1 Interact

It will need to be implemented the tactile interaction with the screen.

2.19.2 Battle

It will need to be implemented a whole turn based battle mechanic.

2.19.3 Rectangle

It will need to be implemented a script to make easy to the player to understand the crafting mechanic but also be challenging, and able to tell if the player is following the correct recipe.

2.20 Schedule

The game of this project is intended to be developed in the following three months.

- First it will be made the scripts about the tactile interaction in the game and the concept art of the characters simultaneously.
- Then the mechanic of crafting will be programmed as the art advances in parallel, creating final designs for the dialogues.
- When the crafting mechanic works correctly, the scripts of the battle mechanic will be made and also the pixel art objects needed for the gameplay. Once both mechanics work fine together it will be programmed the dialogues and it will be added the music and sound effects.

```
void Escogiendo(Guerrero gu)
{
    gu.artifact.GetComponent<Animator> ().SetBool ("Escogiendo", true);
    gu.artifact.overrideSprite = null;
    action.CurrentGuerrero = gu;
    CurrenState = EstadosDeBatalla.ESCOGIENDO;
    action.Show ();
    if (gu.SSsalud.value.Equals (gu.saludMax)) {
        action.buttons [2].interactable = false; //No se puede curar con vida maxima
        action.buttons [2].GetComponentInChildren<Text> ().text = "Salud Máxima";
    }
    else {
        action.buttons [2].interactable = true;
        action.buttons [2].GetComponentInChildren<Text> ().text = "Curar";
    }

    if ((gu.defendiendo) || (gu.defensagrupal)) {
        action.buttons [1].interactable = false; //Ya se está protegiendo
        action.buttons [1].GetComponentInChildren<Text> ().text = "Defendiendo";
    }
    else {
        action.buttons [1].GetComponentInChildren<Text> ().text = "Defenderse";
    }

    if (gu.descansando) {
        action.buttons [3].GetComponentInChildren<Text> ().text = "Recuperando Fuerzas"; //Tras ataque special un turno de recuperacion
        action.buttons [3].interactable = false;
    }
```

3. Project Development

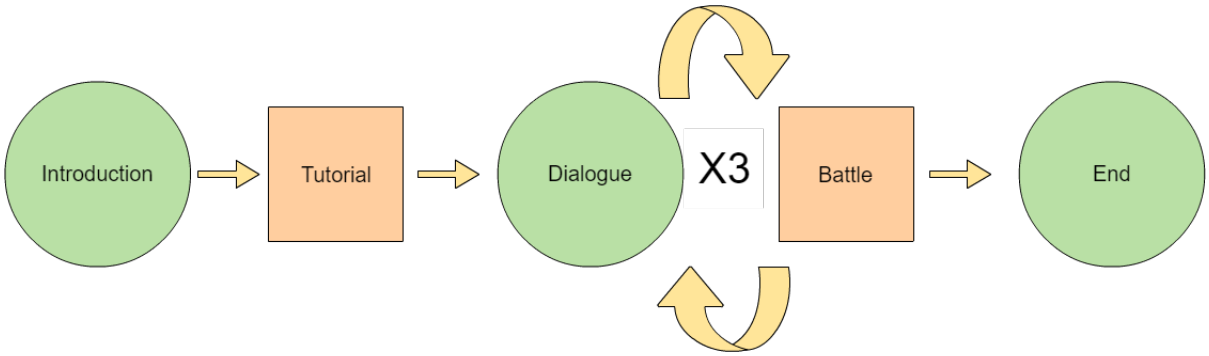


Figure 3.1: Flowchart of Namg.

3.1 Programming

This chapter corresponds to the game development phase. Showing how each task has been tackled. This chapter is focused on the programming tasks since artistic tasks are discussed in the Art section. The Gameplay of Namg will follow the next flowchart.3.1

3.1.1 P1: Tactile Interaction with the screen

In order to program the aspects of the game, first it needs to be corroborated that a tactile game for a tablet can be made using unity, but also since most of the tests will be made on the computer, it is necessary to find a way to treat the cursor like a touch on the screen. To achieve that it is used an *EventSystem*object in the scene, and also the *MouseToTouch* script which handles the Touch inputs from Unity and also creates touch inputs from mouse inputs allowing to play the game on computers.

3.1.2 Programming mechanics

Once the player can interact with the screen using them computer or tablet. The game Namg presents three parts that need to be programmed; the crafting mechanic, the battle mechanic and the dialogues.

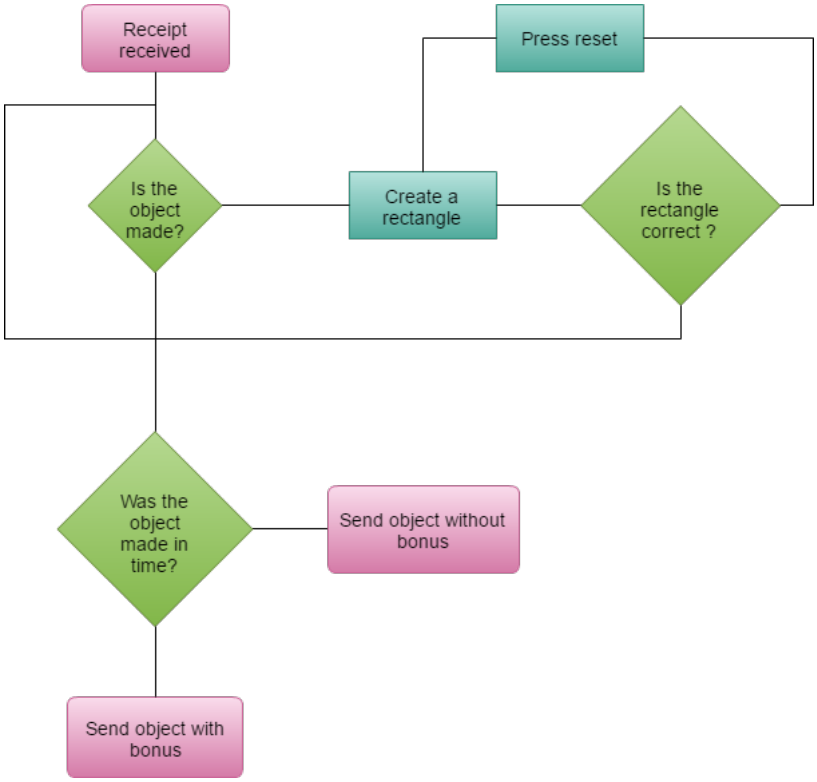


Figure 3.2: The Flowchart of the crafting mechanic.

3.1.3 Crafting Mechanic

Related tasks:

- P3 Algorithm to select the object to make and its recipe
- P4 Algorithm to check the rectangle made.

Since this is the most original mechanic of the game and the one that is didactic, this is the first mechanic that needs to be implemented. Before writing any code, it is advisable to think how many classes are needed. This mechanic uses four classes; *Craft*, *MouseToTouch*, *RowsNColumns* and *Recipe*. A class diagram showing the programming of the mechanics can be seen in Figure[3.4]. This mechanic follows the flowchart from Figure 3.2. After the player has chosen one action for their warrior this mechanic starts, and one recipe is sent to the Craft script to show the player how many pixels of each color the object needs. That is why the script *Craft* has a *Recipe* object, the constructor of this object is shown in Figure 3.3, the script stores how many pixels of each colour needs; the sprite of the object, The time in which the player is expected to craft it and the bonus that adds to the artefact if it's made before running out of time.

```
public Recipe (int roj,int ama,int azu,int nar,int ver,int lila,Sprite sprite,float time,int bonus) {
```

Figure 3.3: The constructor of the class Recipe.

The creation of each rectangle is controlled by the *MouseToTouch* script which follows the

player through the three states of the touch input. After *touch.Began*, the script needs to find the pressed square that will be the start of the rectangle, after that, while the player is moving them finger the script will create a rectangle that could be the solution or could be erased, meanwhile the script *RowsNColumns* is showing the numbers on the border of the table representing the rows and columns giving more information to the player. Once the state is *Touch.Ended* the *RowsNColumns* scripts turn the cells into the colour of the rectangle, to do that task it is used the Refill method from the *MouseToTouch* script, which is a recursive method that receives the start and the end cells of the rectangle and every time it calls itself changes the end cell till the start and the end are the same cell. If one of the cells during the process is already painted, it is called the *Colour* method which receives the color of the cell and the color of the rectangle and returns the additive color, so when the three colors are mixed the result is gray. Also, the already painted cells are stored in a pile, in case the rectangle is not correct and needs to be erased, the *Refresh* method returns to white all the cells with the same color like the rectangle and also empties the pile. To know if the rectangle is correct it is used the *Corroborate* method from the *RownsNColumns* script, which calculates if the area of the rectangle equals the number of cells that is needed of that color.

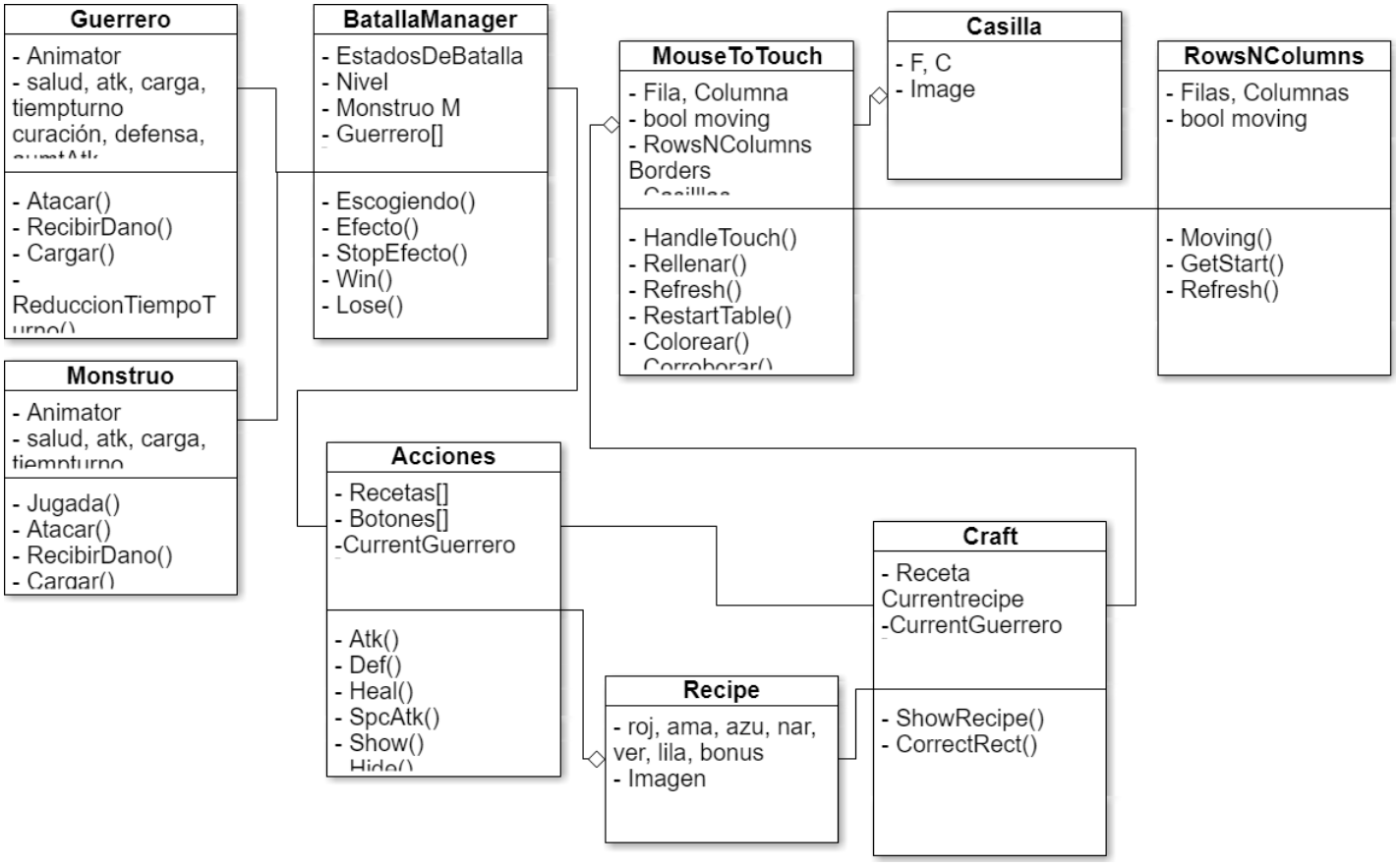


Figure 3.4: The classes used for the Crafting and Battle mechanics.

3.1.4 Battle Mechanic

Related tasks:

- P2 The health of the warriors and the monsters.

To implement this mechanic four classes are used; *BattleManager*, *Guerrero*, *Monstruo* and *Actions*. This mechanic uses the flowchart from Figure 3.5 *Guerrero* is the class for the three warriors of the gameplay and *Mosntruo* is the class with the methods of the monster. *BattleManager* creates three

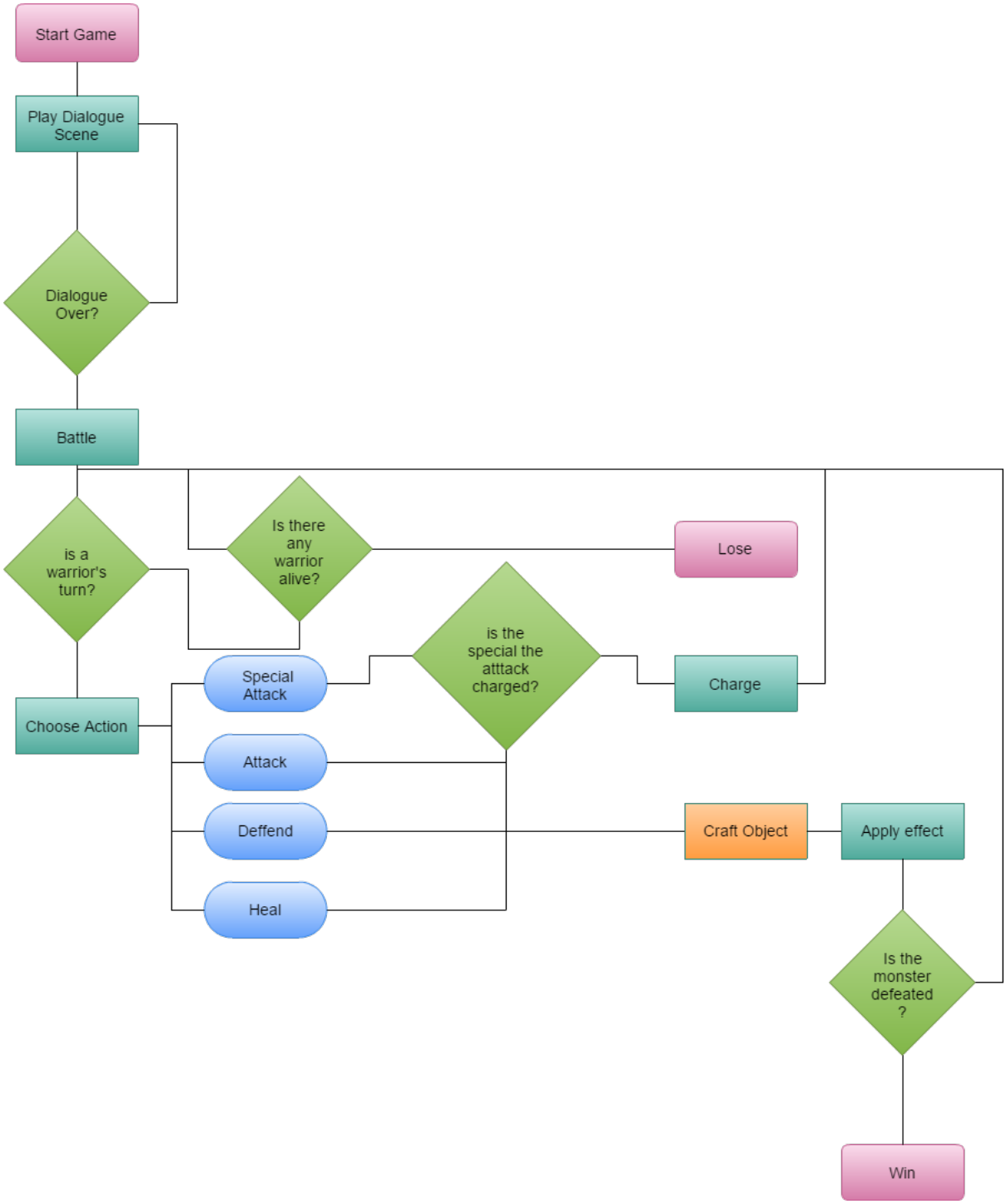


Figure 3.5: The Flowchart of the battling mechanic.

Objects *Guerrero*, one object *Monstruo* and one Object *Actions* which is connected to the buttons of the canvas with methods. *BattleManager* has a state machine that iterates through the states of the fight; Waiting, Choosing, MonsterTurn, Charge, Lose and Win. In the state Waiting, the hourglasses from the battle sliders are moving until they reach the end and it is somebody's turn. In order to energize the battle, every warrior has to wait a different value of time to get them turn, for example, the fastest one is the archer while the knight at the bottom of the scenario is the slowest.

While is a warrior's turn the player can choose one action from the 4 buttons on the screen and the battle stops during this state. Not always all the buttons will be interactive, the method Choosing receives the warrior and enables only certain buttons, for example, if the warrior has full health it doesn't make sense to try to heal them, and also the special attack needs to be charged before the player can use it, after that, the warrior has to wait one turn before charging it again. After crafting one object to a method called *Efecto*, it manages, depending on the action which animation will appear on the character and also a text will let the player know how much power had that effect, for example after crafting an attack object this method will show the attack done to the monster.

After all the warrior's turns it will be the monster's turn so the MonsterTurn state will be activated, then the method *MonsterSMove* is used to choose the proper action, the flowchart that the method follows can be seen in Figure [3.6]. First, if the monster can kill one warrior with their basic attack it will do it, if not it will choose randomly between charging the special attack or attacking a random warrior. However, it is more likely to charge the attack since the special attack hurts the three warriors giving the fight a fun difficulty.

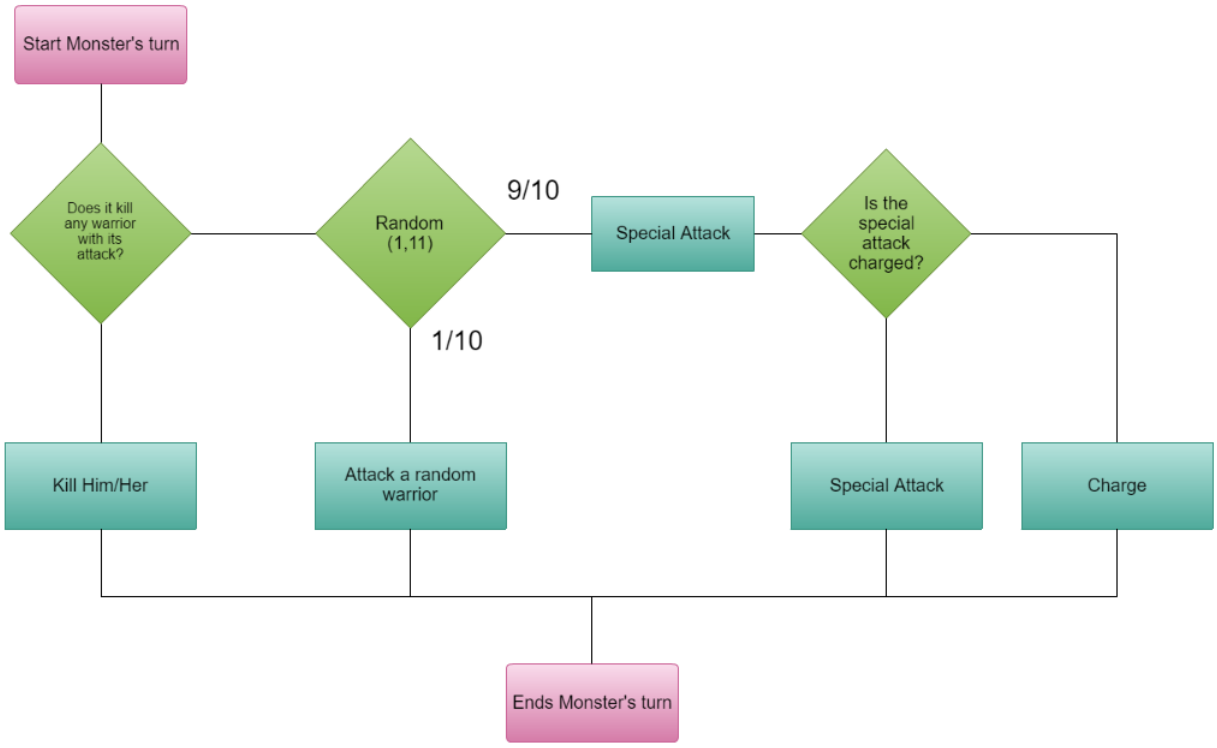


Figure 3.6: The flowchart of Monster's AI.

3.1.5 Dialogues

Related tasks:

- G1 Dialogues to tell the story

- P5 Flowchart between Scenes.

The game uses a plugin from the asset store called Fungus[6] to obtain great dialogues that can be programmed in a more practical way. Although Fungus is used mainly for artists to create games based on storytelling, this games uses a small number of instructions since the objective is to tell a story to be treated as an excuse for the other two mechanics.

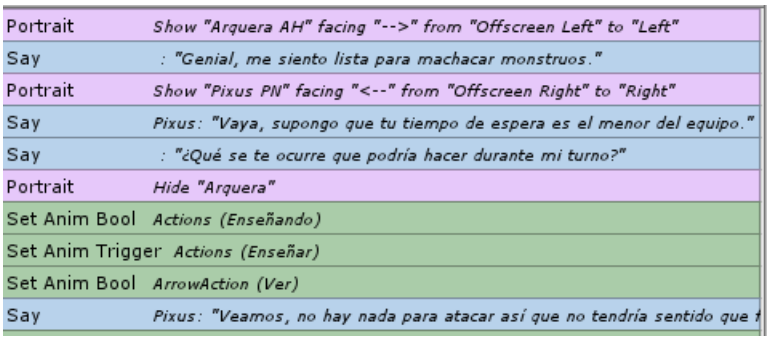


Figure 3.7: The programming loop from Fungus.

Figure 3.8: A picture from a dialogue in game.

As can be seen in Figure 3.7 each kind of instruction has a color, the purple ones are used to show, replace or hide the images of the characters that are in the scenario, there are only three spots, so sometimes the characters need to be replaced for someone from off stage. The blue ones are the sentences that the character says, also as it is shown in Figure 3.8, Fungus Highlights the character that is talking. Also with green instructions Fungus allows the programmer to activate some animations or do some changes on the sprites in the scene. All of the fungus blocks start using a method from the FromIntroToTutorial script, attached to a don't destroy on load object, it is used to control the flowchart between scenes of the game.

3.2 Scenes

Once the mechanics are programmed they need to be put together in different scenes to follow the flowchart shown before [3.1]

3.2.1 Main Menu

This is the first Scene that the player sees, in this scene it is presented a background sprite of the exterior of the house of Namg with mountains in the background. It also has the second logo[4.10] of the game moving up and down and a button to start to play.

3.2.2 Pause Scene

Since the first moment of the game, there will be a pause button in the top right corner of the screen, this button will pause the game and it will let the player click three buttons.

1. "Salir": this button will close the application.
2. "Continue": this button will make all the buttons inactive except pause and it will resume the game.
3. "Guia de batalla": this button will show an image about the special artifacts of the warriors and its effects in the battle. To make easier for the player to win the battles.

3.2.3 Dialogue Scenes

All of these scenes use the dialogue plug-in explained before. With some 2D assets on the background.

3.2.4 Gameplay Scenes

After each dialogue scene, a gameplay scene will follow. In these scenes, the crafting and the battle mechanics work together. Nevertheless more things were programmed in order to improve the experience during the battles.

1. An audio mixer of unity is used in this scene in order to decrease the background music during the sound of any effect, so the player would hear that feedback.
2. A script called BackgroundManager is used to manage the three animations of the background during the battles two birds and one cloud will cross the scenario from left to right with a random height but always higher than the half of the battle scenario so that the cloud could not appear floating touching the floor.

If the player loses, a dialogue will appear and the level will restart, but if the player wins an animation will show a segment of the key as a reward and a group of objects that could appear in the next battle.

4. Art

As mentioned before this game shows to different styles of 2D art, each one with their own tasks.

4.1 Vectorial Art

Related tasks:

- A1 3 sprites per each one of all the 6 characters to use in dialogues
- A4 The 2 environments of the game.

4.1.1 Characters

In order to achieve a representative style for the characters of the game, each type follows a pattern. Two patterns are used in the game, the humans, and the monsters.

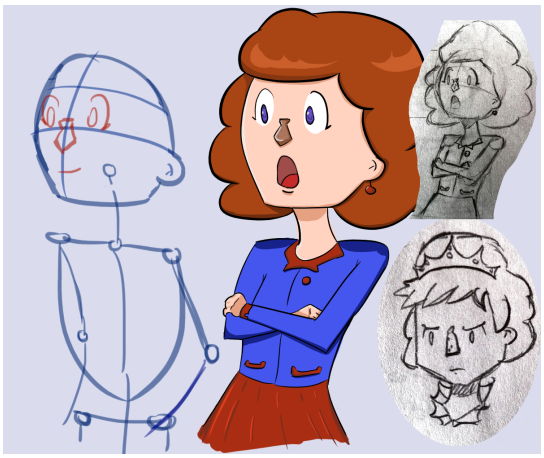


Figure 4.1: The pattern used for the humans characters of Namg, and some examples using this pattern.

Almost all the humans follow the pattern from Figure 4.1, they all have a long neck and a big

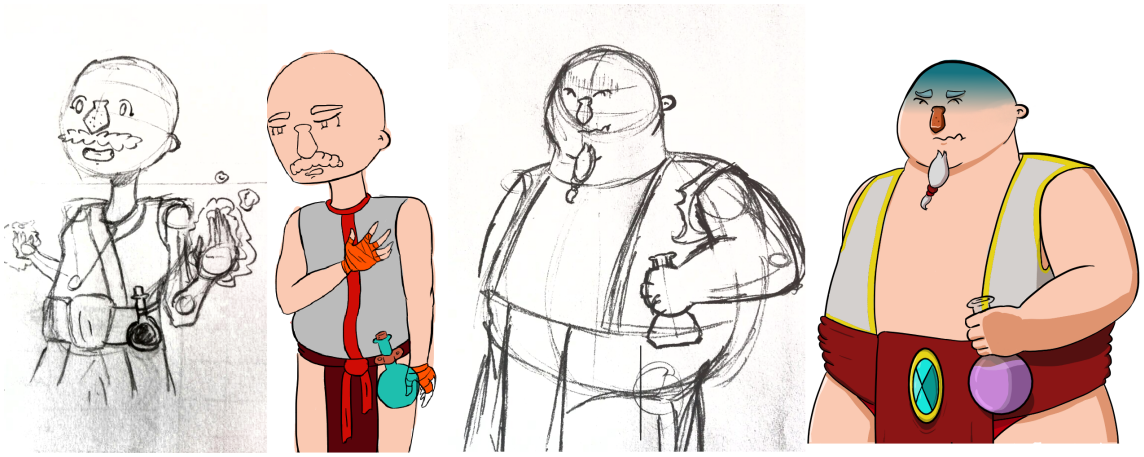


Figure 4.2: The evolution of the design of the mage.

head, on the face they have a black outline around the eyes and a nose in the shape of a diamond. Taking into account that the characters try to represent a varied group of people, the mage could be of a larger composition, therefore the pattern had to be modified for this character. the figure 4.2 represents an example of the mage following the patter and the final design for the character. On the other hand, the demons of Namg follow their on a pattern, as is shown in the body of the demons are compound by five balls, the all have wings like the bats and their colors are normally purple tones. At first, the monsters would have one hand at the bottom of the body, but the tail was thought to be less striking.

Figure 4.3: The evolution of the design of Pixus.

4.1.2 Environments

There are needed two environments in this game.

1. The main menu environment represents the exterior of the house of Namg. It represents a valley with mountains in the background. The house of Namg is also a smithy, the colors of the house are the same as the one used for Namg's clothes.
2. The game play background represents a plain but with two mounds in the background. Using this method the warriors are at different heights an the health and turn sliders do not overlap.

4.1.3 Pixus's Key

During the game, with every victory, Pixus gets back a fragment of the key that he used to open the portal. This key has some features from the demons like the horns and the characteristic tail but also has three pixels of the three colors of the game, each one in one fragment of the key. The final design of the key can be seen in Figure [4.4]

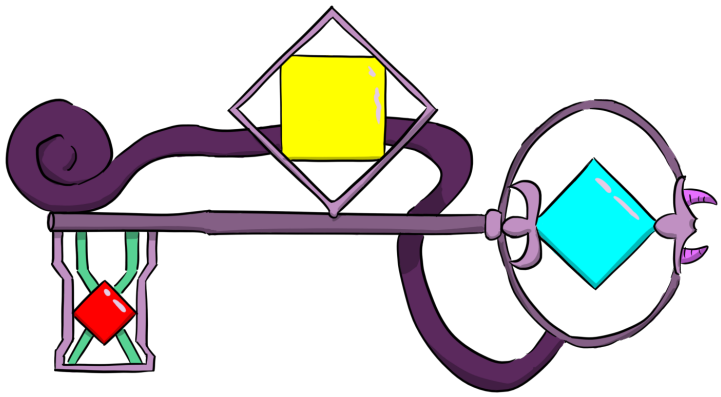


Figure 4.4: The final design of Pixus's key.

4.2 Pixel Art

Related tasks:

- A2 The pixel art version of every character and the 3 monsters
- A3 The animation of the 3 warriors and the 3 monsters
- A5 The pixel art objects
- A7 Special attack animations.

4.2.1 Characters

This game uses pixel art for the battles and the crafted objects.

For the battle the warriors are pixelated, that is why every warrior has their own color palette, to make easier for the player to recognize each warrior, as can be seen in figure 4.5. During the battle the warriors and the monster have their idle animation, which stops if they die.

4.2.2 Pixel objects

To do the pixel art objects for the game, it is needed to bear in mind that the object should possibly be made using the Crafting mechanic, that means that the objects need to meet these requirements.

1. If the object has two colors and the second one needs the previous, for example, the color red and orange, the second number needs to be a multiple of the first, otherwise it can be made with this crafting mechanic.

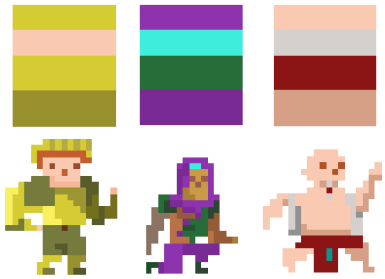


Figure 4.5: The palette used for the pixel art characters.

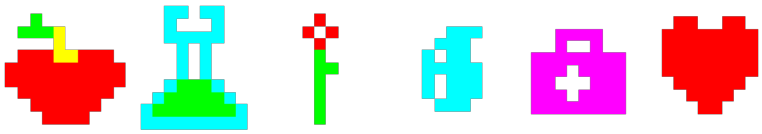


Figure 4.6: Example of objects of healing from the game.

2. If the object is made using one color it has to be made by a number of pixels equal to a result of a multiplication table from one to ten, for example, numbers like thirteen, seventeen or thirty-one can not be made using this mechanic.
3. An object can not be made using secondary colours that are nor followed, for example there is no green and purple object, because after creating the red rectangle, the yellow rectangle can be made anywhere on the table, if the rectangles are separated the blue rectangle can not cover the other two rectangles without leaving blue cells that are probably not part of the recipe.

Following this rules, the game has objects like those shown in figure 4.6. The style of every type of object is explained in the tables 4.2 and 4.1.

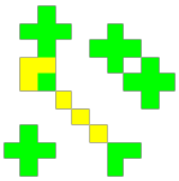
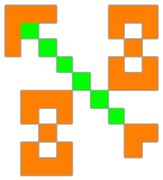
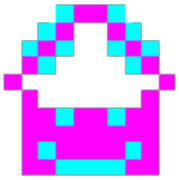
4.2.3 Pixel Art animation

Every time the player uses an object it is shown a different pixel art animation, for example when someone attacks the monster the player can see a slash effect in front of the monster. This effect and the idle are the only ones made with Krita, drawing each frame, the rest are made with the particle system of Unity using custom particles and changing the settings on each effect.

4.3 Task A8:UI

In this game, the player needs to know much information from the screen in order to execute the two main mechanics. That is why many changes have been made in the design during the process of creation, as it can be seen in Figure On one hand the players should be able to see the health of the warriors and the monster, and also if they are under some effect like the defending effect shown at the number 2 in Figure 4.8, that is why at the top left corner, where the battle takes place, each warrior and monster has two bars above them, the green one is the health and the other one is the wait for the turn, as it can be seen at number 1 in the same figure. On the other hand, the rest of the screen is for the crafting mechanic. At the number 3, the player can see the possible actions

Table 4.1: Pixel Art Objects (Special Attacks)

Special Attack Objects		
	Knight	
	Represents a sword wrapped in flames	Is more powerful than regular attacks.
	Represents a medieval bugle	It augments the attack of the warriors.
	Archer	
	Represents an arrow wit green crosses	It heals the warriors.
	Represents an arrow with hourglasses	It augments the wait value of the enemy to get its turn.
	Mage	
	Represents a home	Shields all the warriors.
	Represents a DNA strand	It reduces the wait value of the warriors to get them turn.

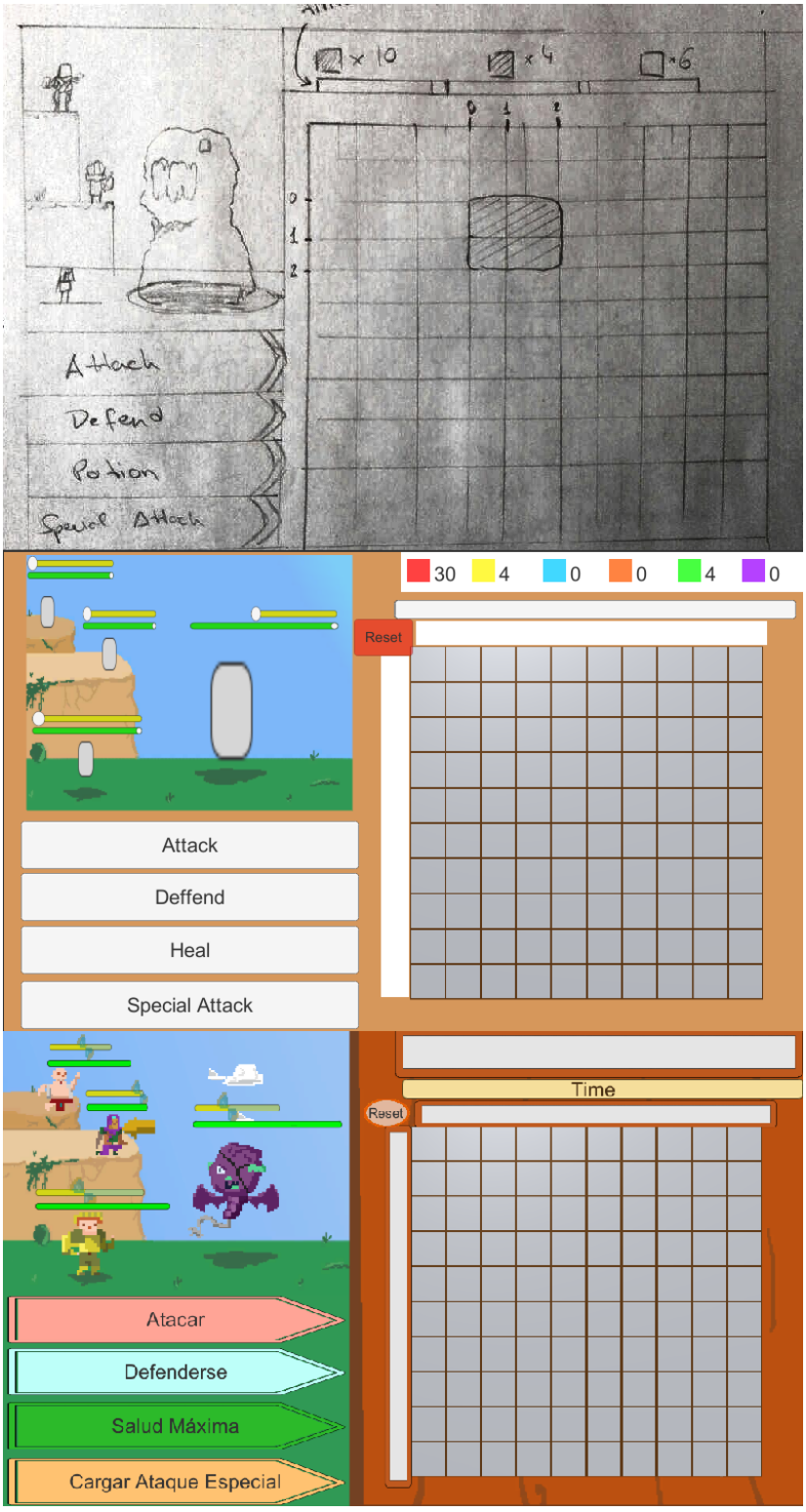
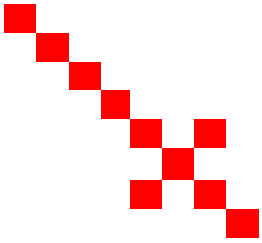
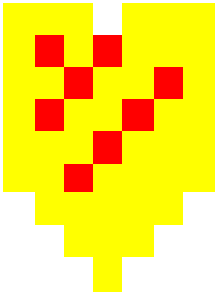


Figure 4.7: The evolution of the design of the gameplay.

Table 4.2: Pixel Art Objects

Object	Description	Effect
Attack		
	The attack objects look like medieval weapons, like knifes and swords	They reduce the heal of the enemy.
Defend		
	The defend objects look like shields, helmets or spells	They augment the defence of the character.
Heal		
	The heal objects look like food, potions or medieval remedies	They augment the heal of the character.

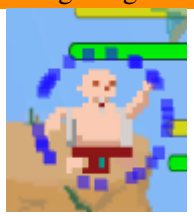
that they can make. At number 4 the player can see the recipe of the object, where the red pixels number is green because that part is already complete. Above the number, there is the reset button. Finally, during the creation of a rectangle the player can see the number of cells of the height and width of the rectangle.

4.4 Task A9:Logo

The logo of the game Namg is an "N" in order to be easy to relate to the game, but also it should represent some of the mechanics or the style of the game. Keeping that in mind it was made with pixels from the three colors of the game inside the N and from the three designs that came out, was chosen the number 2 of the figure 4.9.

This logo it is thought to be for mobile phones, however during the game the player can see another logo that also represents the spirit of the game as shown in Figure 4.10, it has the same font that the other logo but the colour is the same that one of the main colours of the character Namg and also three squares can be seen, each one represents one of the three main colours of the gameplay.

Table 4.3: Pixel Art Animations

Image in game	Effect	Image in game	Effect
	Defend animation: blue pixels surround the warrior		Aumegted attack animation: orange pixels rise from the ground
	Healing animation: green crosses rise from the ground		Charging animation: orange pixels go from a circle that surrounds the warrior to the centre
	Monster ready for the special attack: Red pixels surround the monster		Hurt animation: a slice goes through the character
	Monster's special attack: red pixels go from the monster to any direction		Fireworks: Once the monster is defeated, fireworks will appear to announce the victory

4.5 Task G2: find music and effects

Considering that the most part of the game is in pixel art. The music that usually goes really well with that is 8-bit. All of the effects were found in the freesound8 platform, searching for themes like a punch, slice or teleport. However, for the background music, it was used the web Free Music Archive where it can be found the whole soundtrack of a pixel art game, one of the songs of the CD[4.11] is used for the main menu scene. For the main menu scene and during the dialogues two songs will be played, both of them are relaxing and not strident at all, because it is when the player is starting the game or reading the dialogues about the story and characters, however, to make a contrast, a different song is played when during the dialogues the next monster enters to scene, this song anticipates a fight so it is most lively. During the battles, it is played a different song with a faster beat more related to a battle type song.

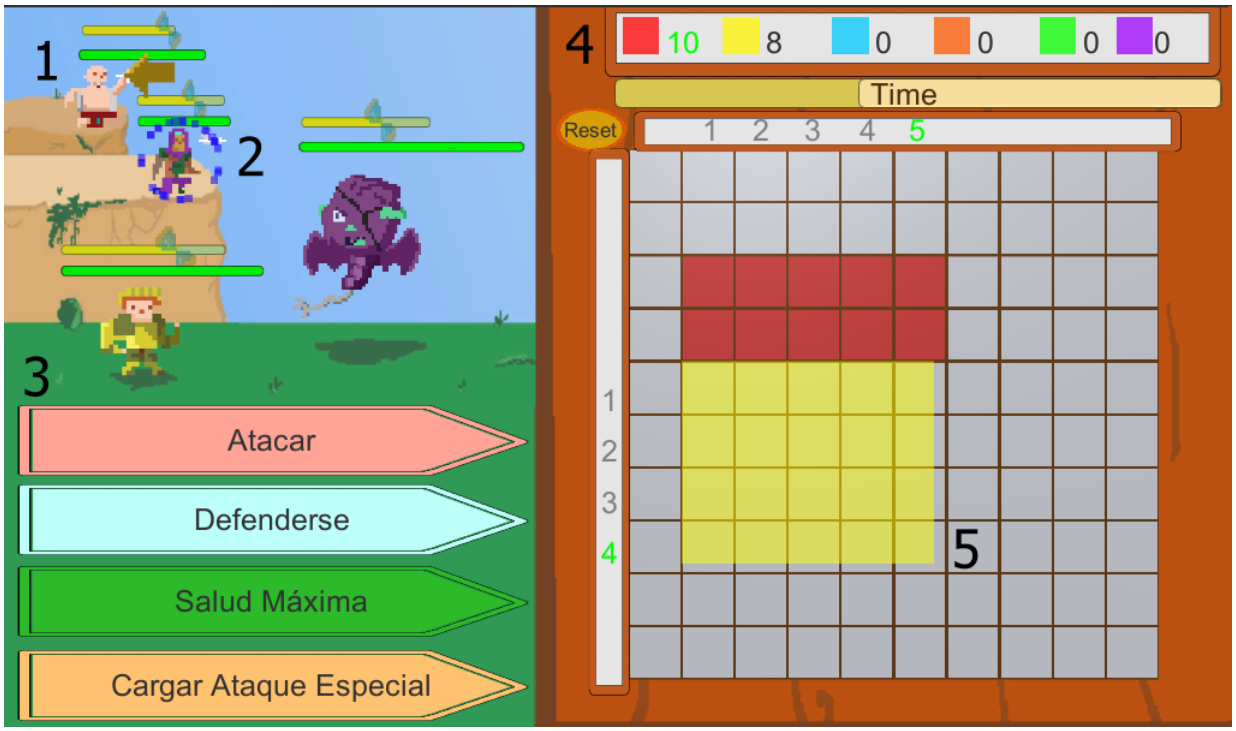


Figure 4.8: The gameplay screen.

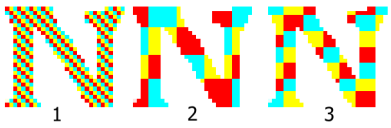
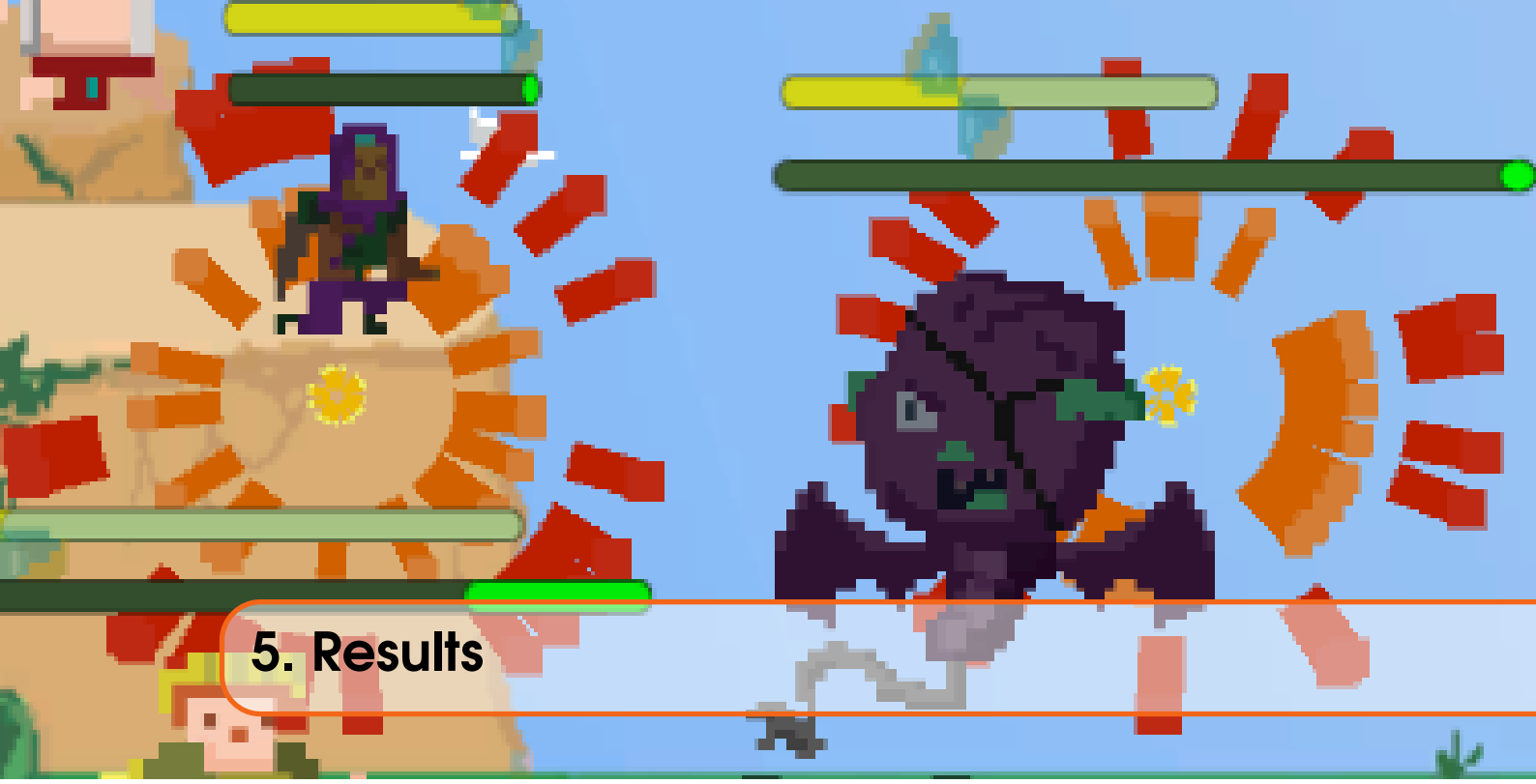


Figure 4.9: Some designs of the Logo of the game.

Figure 4.10: Logo that can be seen during the gameplay.

Figure 4.11: The CD used for the game named "Songs From An Unmade World 2".



5. Results

During chapter one, a series of deliverables related to some tasks were presented. This section consists on a presentation of the final state of each one of the intended results of this project.

5.1 Technical Proposal

The document describing the intended work for this final project which is the first chapter of this dissertation.

5.2 Game Design Document

The GDD explains all the game design aspects of the game Namg.

5.3 Game Development

It will consist on "a technical document describing all the work done in this final project" which refers to the thesis you are currently reading.

5.4 The Application "Namg"

The application for Android Namg is the result of much of the effort in this project. The application gets to cover the whole story of the game and contains the three fights with the different monsters, as discussed in Chapter 3 Project Development. It allows the player to test the mechanics previously presented in Chapter 2 Game Design Document, as well as ordering actions to the warriors and crafting objects. All accompanied by visual and sonorous feedback. Because the crafting mechanic is not something that the average player is used to, the game shows a tutorial to teach how that mechanic works, as well as presents the story and the characters. The last version of Namg can be downloaded using this URL, or using the QR code [5.1]. `https://drive.google.com/drive/folders/0B2B3i_4D1AqiMTBOR0ZKS0xQV1U?usp=sharing`

The figure[5.2] shows many scenes taken from the gameplay of the game. Additionally, the table [5.1] contains a specific listing of all resources generated for the project.

Figure 5.1: QR code link to the download site.

5.5 Project Defense Video

A video of two minutes of duration will be made to defend the proposal. This video will show different scenes of the gameplay of Namg and can be seen through this URL. `https://drive.google.com/open?id=0B2B3i_4D1AqiRm51Ulg4eV8za1U`

5.6 Project Defense Presentation

The presentation to be used during the project defense is currently under construction but is accessible at this URl.
`https://docs.google.com/presentation/d/1cSCYqGnT_Cydbd534yjvW7F5py6Ig18C5GIyL9V9LuY/edit?usp=sharing`

Figure 5.2: A sequence of scenes taken from the Namg gameplay.

Table 5.1: Resources made

Resources made	
Art	
The conceptual design of nine characters	
21 vectorial style assets	
1 vectorial style background	
42 pixel art style assets	
1 pixel art style background	
9 Animations frame by frame using Krita	
11 Animations using Unity	
Programming	
4 C# classes	
10 Monobehaviour scripts	
4 Monobehaviour scripts with some changes for the tutorial	
Code Lines	
Script	Lines
Guerrero	176
Monstruo	140
Quad	130
Recipe	20
MouseToTouch	400
BackgroundManager	75
Pause	79
Skip	56
FromIntroToTutorial	110
BatallaManager	495
Acciones	327
ChangeRectangle	104
Craft	217
RowsNColumns	183
Total	2512

6. Testing and Evaluation

This section is divided into two subsections. On the first one it is tested the quality of the final project and on the second one, it is tested the performance of the project.

6.1 Testing

Ensuring the correctness of the system is not sufficient when testing games. Entertaining, a transmission of emotions and a development of skills are purposes inherent in games that must be examined too.

6.1.1 Verification

The verification phase guarantees that the application is free of any kind of bugs. This process is normally performed on 4 distinguishable phases: development phase, alpha, beta, and release. On each phase, different sets of actors test the product including developers, professional game testers, and users. In our case, thanks to limitations in time and budget, the assurance on the correctness of the application was performed by the developer and some testers.

6.1.2 Validation

The process of checking that a game accomplishes its intended purposes can be labeled as validation. Developers are typically biased to some extension with their game so validation must be performed by external parties. In order to achieve that, the second version of the game was given to some testers with different level of knowledge of video games. In this version, they have to pass the tutorial, kill the three monsters and then fill the next form.

Test Namg (Not Another Multiplication Game)

This questionnaire collects information about Namg's game play. Thanks in advance for your contribution.

Demographics

1. **What is your age?**
   Marca solo un óvalo.
   - Under 12 years old.
   - 12-17 years old.
   - 18 years or older

2. **How often do you play videogames?**
   Marca solo un óvalo.
   - Rarely
   - Once a week
   - A few times a week
   - About once a day

Quantitative

Rate from 1 to 5 (1-Strongly disagree,3-Neutral,5-Strongly agree)

3. **Did you find the game entertaining?**
   Marca solo un óvalo.

1	2	3	4	5
◯	◯	◯	◯	◯

4. **Did you find the tutorial useful?**
   Marca solo un óvalo.

1	2	3	4	5
◯	◯	◯	◯	◯

5. **Did you feel lost at some point during the battles?**
   Marca solo un óvalo.

1	2	3	4	5
◯	◯	◯	◯	◯

6. **Did you like the visual style of the game?**
   Marca solo un óvalo.

1	2	3	4	5
◯	◯	◯	◯	◯

7. **Did you find the story of the game interesting?**
   Marca solo un óvalo.

1	2	3	4	5
◯	◯	◯	◯	◯

8. **Do you think it helps to refresh / become familiar with multiplication concepts?**
   Marca solo un óvalo.

1	2	3	4	5
◯	◯	◯	◯	◯

9. **Did you find the game overly difficult?**
   Marca solo un óvalo.

1	2	3	4	5
◯	◯	◯	◯	◯

Final questions

10. **What did you dislike about the experience?**

11. **Was anything confusing?**

12. **In your opinion, what needs to be improved?**

13. **Name a game you have seen or played that Namg reminds you of.**

14. **Any final thoughts or comments you would like to add?**

Thank you for your time.

After the first playtesting

Thanks to all of the testers that played the game, some errors were found and some things were corroborated.

Good things

- People often like the visual style of the game.
- Older players recognized that the game refreshed certain multiplications they had forgotten.
- Most people understood the story of Pixus and found it entertaining.
- No tester knew of any game whose mechanics resembled those of Namg.

Not so good things

- The tutorial was necessary but the way to do it was a little boring.
- Many testers were stuck in complex objects even though they had knowledge of multiplications.
- To some testers, the battles seemed rather long.
- Some music changes were very abrupt.

Another restriction on the pixel art objects

During this play testing, a new restriction on the pixel art objects was found.

- When an object is made by two primaries colors the first color has to be the larger number, otherwise the player could leave no space to do the second rectangle. An example of this is found in the original "yellow shield" which was change to red to solve this problem as is shown in Figure[6.1].

6.1.3 Changes from this play testing

After reading the testers' opinions about the gameplay, the bonus of some objects was increased and the life of the enemies was reduced so that the difficulty was more progressive upward. Finally, those texts that had errors were fixed and the possibility of choosing the background music and effects volume was programmed.

6.1.4 Evaluation

In this section, the performance of the game is analyzed.

Hardware

The characteristics of the hardware used during the evaluation process can be found in Table[6.1]. The game runs perfectly in all of the three platforms.

Table 6.1: Specifications of evaluation devices

Specifications of evaluation devices			
Namet	Asus Laptop	HP Tablet	Huawei Mobile
Model	X750JN.TY04IH	Pavilion x2 10 K020NS	ALE-L21
Operative System	Windows 10 Home	Windows 10 Home	Android 6.0
Processor	Intel Core i7.4710HQ 2.5 GHz	Intel Atom Z3736F 1.33GHz	HiSilicon Kirin 620 1.2 GHz
RAM Memory	8GB DDR3 1600MHz	2Gb DDR3 1333MHz	2.0GB
Graphics Card	Nvidia GeForce GT 840M 2GB DDR3	Intel HD Graphics	(GPU) Mali-T830MP2

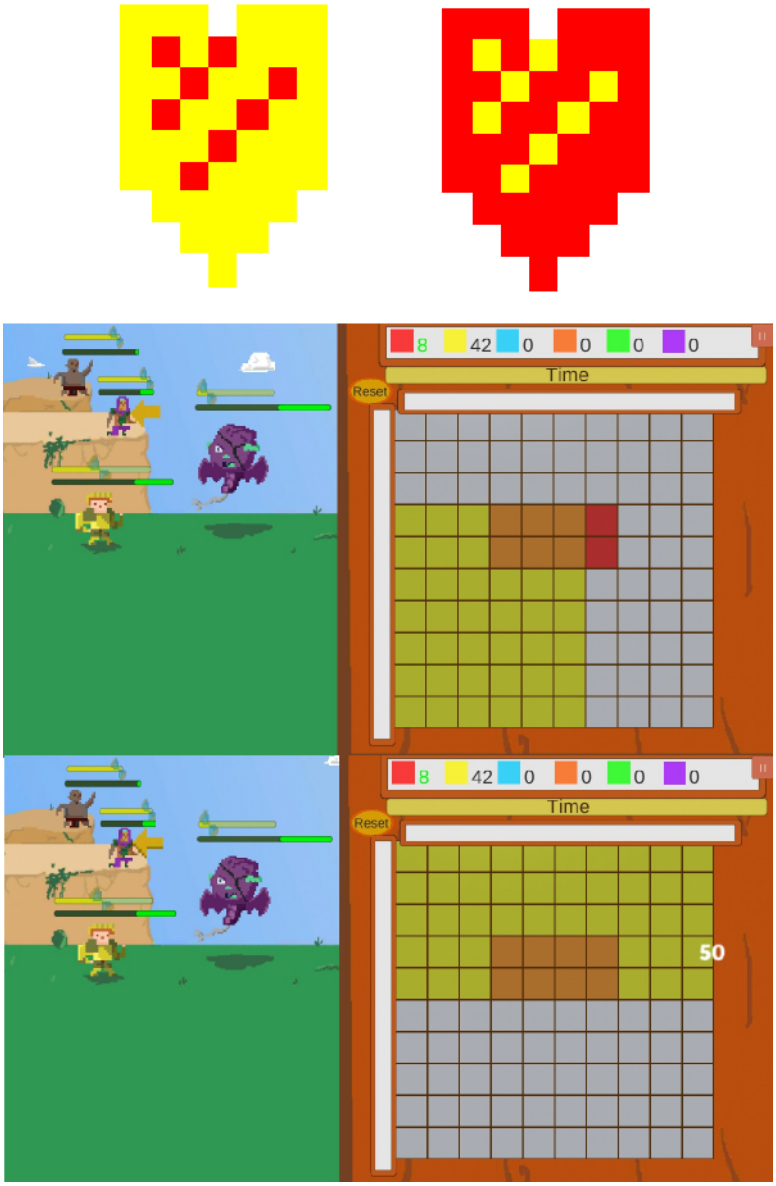


Figure 6.1: The problem of the "yellow shield" during the gameplay.

7. Project deviation

During the development of the game Namg, some changes were made in order to adjust the project to the technical proposal's schedule, but most important to make the player experience as gratifying as possible.

Design changes

7.0.1 Recipe of objects with secondary colors

One of the first decisions that needed to be made related to the crafting mechanic was, how to tell to the player how many pixels of a secondary color is needed. This will be explained with the tutorial object, the apple, and knowing that the only colors that the player can use are red, yellow and blue. One way is to show in the recipe the total number of pixels that are needed, In this case, would be 30 red pixels, 8 yellow, 4 blue and 4 green, but that could be a little tangled, since when the player creates the 4 green pixels the yellow ones no longer exists so they can not be used in the object. The other way is to show only the pixels of the color that will be part of the object, and the player will have to know which primary color uses and sum up the primary pixels with the secondary colors pixels. In this case, the recipe shows 30 red pixels, 4 yellow and 4 green, so the player has to know that they will need 8 yellows and 4 blue to complete the recipe. Both ways were tested during the development of the crafting mechanic and the one that seemed easier to understand was the second one, which is the one that the game uses.

7.0.2 The charges needed for the special attack

When the first version of the game was tested for the special attack the warriors and the monster would wait for 3 turns. This would slow down the gameplay and increased the possibility that the player did not choose this action. Taking that into account the number of charges for the warriors was change to 1 and 2 for the monster, with this change the battles are more difficult but less monotonous since the special attacks of the warriors are most of the times the key to win the battles.

Programming changes

7.0.3 Rectangle during Touchphase.Moved

In the first version of the crafting mechanic the rectangle was painted using the cells of the table, but using this method, was more difficult for the player to see the relation between the position of them finger and the corner of the rectangle, after some feedback that method was discarded and the second method uses a rectangle object that follows the touch position of the player.

Art changes

7.0.4 Pixu's Key

Even though the most tasks of this section were made successfully, some of them were not specific enough. Also after testing the first version of the game the asset of the Pixus's key was needed in order for the battles to make sense, giving a reward to the player.

7.0.5 Task A7: Special attack animations

Not only special attack animations were needed during the development of the game. The task A7 was extended to include all the battle animations that are needed to give the necessary feedback to the player.

7.1 Project Schedule

In the section 1.2.2 of the Technical proposal it was presented the estimated schedule for this project, during the development of the project some tasks were added and some others showed that they were overestimated in terms of time. The Table [7.1] shows the tasks and the time modified.

7.2 Budget

This section explains an estimate of the money it would cost to carry out the project.

7.2.1 Human Resources

The cost associated with human resources is obtained from the average and the maximum 2017 contribution bases and rates stipulated by the Government of Spain, for the computer engineer would be 3.750 €per month and the average salary for an artist would be 1500 €per month. The artist would be paid for the artistic tasks and the rest would be for the computer engineer.The cost of the human resources are shown in Table [7.2]

7.2.2 Hardware

The hardware for this project would be used for its development and also its evaluation. The cost is reflected in table [7.3]

7.2.3 Software

All of the software used for the project is open source and free, so the cost would be 0.

Table 7.1: Tasks and time

Tasks that have been modified			
ID Task	Description	Estimated hours	Hours needed
Art			
A1	3 Sprites per each one of all the 6 characters to use in dialogues	36	
A1.1	Between 2 and 3 sprites per each one of all the 4 human characters uesd in dialogues	0	24
A1.2	One sprite per each of all the 5 demons characters to use in dialogues	0	10
A2	The pixel art version of every character ant the 3 monsters	18	
A2.1	The pixel art version of 3 warriors and 3 monsters characters	18	16
A3	The animations of the 3 warriors and the 3 monsters	12	8
A4	The 2 environments of the game	5	5
A5	The pixel art objects	8	10
A6	Animations on the environment	6	6
A7	Special attck animations	4	
A7	Battle animations	4	6
A8	UI	5	5
A9	Logo	2	2
A10	The asset of the Pixus's key	0	2
Programming			
P1	The tactile interaction with the screen	6	10
P2	The health of the warriors and the monsters	24	
P2.1	The complete Battle mechanic	0	26
P3	Algorithm to select the object to make and its recipe	24	24
P4	Algorithm to check the rectangle made	20	18
P5	Flowchart between screens	6	4
P6	Music in the scenes	0	2
Documentation			
D1	Lectures about TFG	8	8
D2	Technical Proposal	12	12
D3	Game Design Document (GDD)	40	40
D4	TFG Document	45	45
D5	Project Defense Video	2	2
D6	Project Defense Presentation	2	2
Game design			
G1	Dialogues to tell the story	10	10
G2	Find music and effects	5	5
Total		300	300

Table 7.2: Human Resources

Human Resources			
Role	Base/h	Hours	Cost
Engineer	15.62€	188	2937€
Artist	6.25€	112	700€
Total			3637€

Table 7.3: Hardware

Hardware owned			
Concept	Price per unit	Amortization per month(2 years)	Cost (5 months)
Personal computer	400€	16.66€	83.33 €
Tablet	320€	13.33€	66.66€
Total			149.99€

7.2.4 Consumables

This is the cost of all the consumables that will be spent, like pens, staple, printer ink. which is shown in table [7.4]

Table 7.4: Consumables

Consumables	
Concept	Cost
Office material	50 €
Totals	50€

7.2.5 Other costs

Encompasses any other cost which cannot be fitted in previous sections. Indirect costs incorporate expenses linked to the project (maintenance, electricity, internet, etc.) and are represented by 20 % of the human resources costs. It can be seen in table [7.5]

7.2.6 Total

The table [7.6] shows the total of the cost of the project. the price before taxes and after taxes(21%).

Table 7.5: Other costs

Others costs	
Concept	Cost
Indirect cost	737.4 €
Totals	737.4€

Table 7.6: Total

Total	
Concept	Cost
Human resources	3637 €
Hardware	149.99 €
Software	0€
Office material	50 €
Indirect cost	737.4 €
Totals	4574.39€

8. Conclusions

This document presented Namg, as a serious game that can be used to help children getting familiar with multiplication concepts, using an entertaining game play. The project included the design, development and proper documentation that had to be adjusted to a time schedule. First, it was presented a Technical proposal explaining how the skills learned through the degree were to be used in this project. Furthermore, a list of objectives was presented in that chapter.

8.1 Objectives

- One of the objectives was to develop a full-featured game. As it can be seen in chapter 3 "Game development", the game follows a flowchart that let the player play a tutorial and then three battle against three different enemies, after that the game has an end, and the player can repeat the story. So in that aspect, the testers don't feel the game as something incomplete or without an end, the story ends when Pixus gets to cross the portal and closes it.
- The second objective was to give the game a complete artistic style in tune, this was accomplished creating the artistic tasks during the Technical proposal. Then, during the development of the Game Design Document two styles were chosen based on the influences, one for vectorial art and the other for pixel art.
- The third and last objective was to design a game that helps people to improve their multiplications skills. Due to the limited time, it has not been able to do a complete study on children to find out if their academic performance improved. However thanks to the play testing presented in Chapter 6. The game has been demonstrated as a minimum that helps to reinforce concepts of multiplication.

8.2 Future work

Even though the game Namg was aimed to be a brief serious game with beginning and end, some ideas were not implemented. Some for lack of time and others did not seem to help with the main objective of the game, however, projects of this type can always grow in different directions.

8.2.1 Final weapons

The idea was to make the player to create a more complex weapon at the end of the battle to give the final blow to the enemy, this weapon would be separate in three components, and each warrior would have to craft one component. This idea is due to the limited number of pixels offered by the table if an object uses three tables could be created larger objects and therefore cooler like huge pistols or even invocations.

8.2.2 More Warriors

In the game the player only sees three warriors from the village, However, could be an interesting idea that every warrior had their own objects, not only special attacks, and also meet new population with different particularities, for example, a witch, a dwarf, an assassin, etc. Doing that the player would choose which characters want in their team of three. But, on the other, the number of objects would be smaller and the player could get bored of crafting the same objects.

8.2.3 Arcade Mode

Since the main objective of the game is to make children remember the multiplication tables while having fun. The story during the game is great for the mechanics to make sense, but after beating the game once, would be great to unlock a new arcade mode, where you earn points defeating enemies one after another and then use that points to buy rewards, like changing the clothes of the characters or buy new and more powerful pixel objects.

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